Industrial Processes

Fact Sheet

Take several hundred tons of molten iron, add oxygen and carbon, cook at 3000 degrees Fahrenheit.

This simplified recipe for steel contains a step common to many industrial processes: starting materials are transformed into a product using high-temperature processes. The challenge is to monitor, control, and increase the efficiency of the conversion process, and to improve product quality.

The Combustion Research Facility (CRF) collaborates with a variety of industries to understand the chemical and physical behavior of materials undergoing high-temperature conversion processes. This work ranges from fundamental theoretical and experimental research to applied modeling and demonstration experiments. Many of the experiments use well-controlled laboratory reactors that simulate the key features of a practical industrial processing system, allowing researchers to make measurements, alter operating parameters, and reconfigure processes in a controlled environment without resulting in downtime in actual manufacturing processes.

Optical Diagnostics

The use of optical diagnostics is a common feature in experimental reactors and a distinguishing feature of the CRF. These are used to measure temperature, velocities, and species composition within process environments.

Steel

Making steel is a high-temperature process requiring a tremendous amount of energy. The American Iron and Steel Institute (AISI) estimates that the approximately 19 million BTUs per ton of steel shipped represents 2 to 3 percent of the total energy consumed in the United States.

Molten iron is charged into one of Bethlehem Steel's basic oxygen furnaces.

Since 1993, the CRF has been working with AISI to help improve the steelmaking process through optical diagnostics and process control. The multiyear collaborative research program receives 70 percent of its funding from the Department of Energy.

The CRF's work has focused on the basic oxygen furnace, which is used for making slightly more than half of the country's steel. Inside the furnace, molten iron is converted to steel by injecting oxygen and burning off carbon. The challenge is to dynamically control the process by measuring the melt carbon concentration and accurately predicting the final melt temperature in an extremely hostile environment: gas temperatures above the molten iron can reach more than 3000 degrees Fahrenheit.

CRF researchers are developing optical sensors that are able to make measurements inside the furnace and in the vapors above the furnace without stopping or interfering with the process. Patent applications have been submitted for these sensors. The collaboration also involves Insitec Measurement Systems, a small San Francisco Bay Area-company that was started by a former CRF researcher to commercialize a particle measurement system. Because of the project's success, efforts are underway to extend the optical measurement techniques to the electric arc steelmaking furnace.

Glass

Like the steel industry, the glass industry is a major energy user, and the manufacturing process involves high-temperatures and combustion-driven processes, making the CRF a logical partner for tackling some of the industry's challenges.

One collaborative project with the glass industry involves the development of new coating processes for "float" glass. Float glass is named for its manufacturing process in which flat glass is formed by "floating" molten glass on a bath of molten tin. Coatings are applied to the hot glass while it is on the float line; one of the most common materials used is tin oxide. Coatings change the optical properties of the glass to improve its insulating ability. So-called "low-E" glass uses a coating to help increase a building's energy efficiency by strategically transmitting or reflecting the sun's energy. More than 2 million tons of float glass are used annually in residential and commercial construction.

CRF researchers are collaborating with Libbey-Owens-Ford Co.(LOF), a Toledo, Ohio-based manufacturer of glass for architectural and automotive applications. LOF is working to develop new coatings and coating deposition processes as well as diagnostic techniques for monitoring the coating manufacturing process. CRF researchers are involved in all phases of this work and are using both experimental and computational techniques to obtain a more fundamental understanding of the

Float glass after coating to improve its optical properties is allowed to cool and then cut on line. The glass ribbon shown here, which moves continuously at approximately one foot per second, is more than twelve feet wide.

thermochemistry and kinetics of coating formation.

Another CRF collaboration involves working with Gallo Glass, Corning, and Visteon Automotive Systems (a division of Ford Motor Co.) to develop the Glass Furnace Combustion and Melting User Research Facility. The facility will feature a pilot-scale glass furnace that will allow manufacturers to conduct research for the purposes of optimizing furnace design and melting processes. The furnace, which will be capable of melting several tons of glass per day, will be outfitted with optical diagnostic equipment that will allow remote measurements of important operational parameters. Plans call for construction of the furnace to begin in Fall 1999.

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